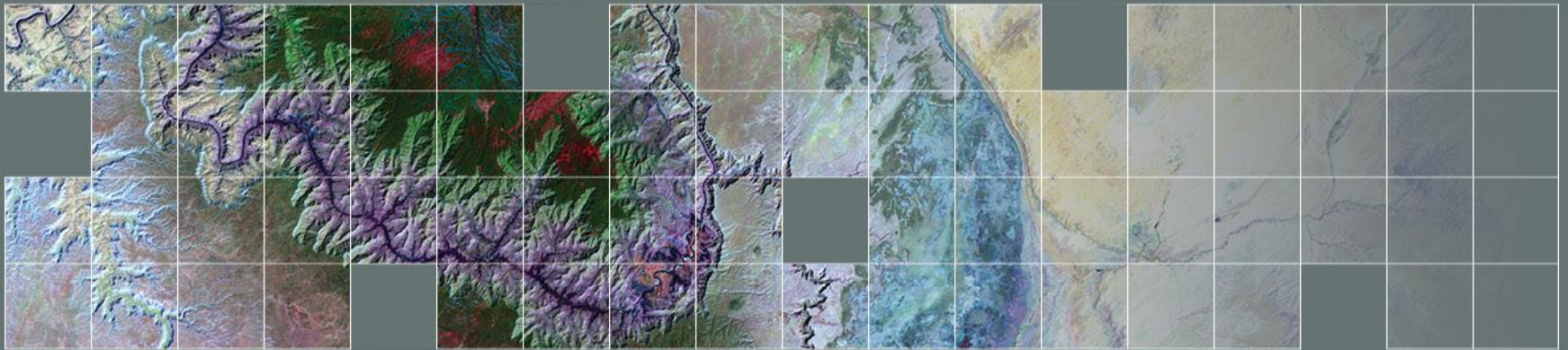**Climate and Land Use Change**
Earth Resources Observation and Science (EROS) Center

USGS and NASA Sentinel-2 Status

John Dwyer & Jeff Masek
July 7, 2015
Landsat Science Team

U.S. Department of the Interior
U.S. Geological Survey

USGS Plans for Sentinel-2 Data

- **Presented Investigation Summary "Sentinel-2 Augmentation to Landsat Data Record" to Land Remote Sensing Program October, 2014**
  - Scope and Ops Con assumptions used for analysis
  - Investigation Analysis & Findings
  - Architecture Recommendation & Implementation Summary
  - Risks & Considerations
  - Work packages and associated cost estimates
- **Collaborating with NASA on pre-flight calibration to data characterization to define Science data processing to ensure Landsat and Sentinel-2 data synergy**

≈USGS

Implementation Tiers and Options

- **Implementation Tiers:**
  - ✓ **Tier 1: EROS will pull a copy of all L1C data from ESA, host a copy at EROS, generate a Full Resolution Browse (FRB) and enable basic data discover capabilities (no other processing included)**

  - **Tier 2:** In addition to Tier 1, add a minimal amount of processing necessary to increase usability of the data, including reformatting data to be more consistent with Landsat Level 1 and resampling the Level 1C data to a 30m common grid and tiling scheme (Landsat-like) for distribution as an on-demand Landsat-like product

  - **Tier 3:** This is a separate and parallel scenario to Tier 2 to render the MSI data interoperable with Landsat and significantly increase the usability/utility of the data for research/applications and makes the data as seamlessly similar as possible to Landsat data for the user (feasibility pending and therefore, not yet estimated)

- **Additional defined options:**
  - ✓ **Option 1: Increase disk cache for S2 data from 180 days to 360 days and add 10% each year (base assumption includes 180 days of spinning disk) to improve user experience**

  - **Option 2:** Generate surface reflectance products from S2 data and archive and distribute to the public (currently assuming use of NASA Ames Research Center (ARC) for processing SR data)

  - **Option 3:** Provide coincident search and discovery of both inventories (Landsat & S2) simultaneously in EarthExplorer and provide aggregated results (feasibility pending and therefore, not yet estimated)

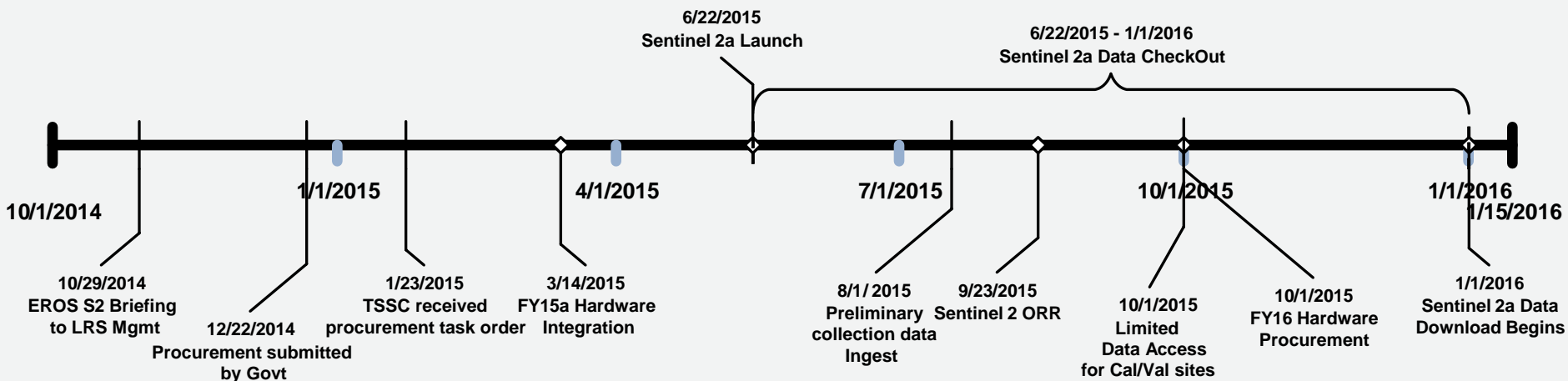- **Scope and Schedule remain contingent upon available funding**
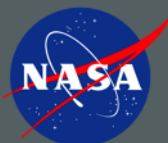
FY15 Milestones and Deliverables

Executive Milestones	Status	Start Date	End Date	Notes/Deliverable
FY15a Hardware Procurement Submission (2 months IT approval, 1 month TSSC award, 2 months to purchase and delivery)	In Process	Nov 2014	May 2015	Hardware procurement critical path – if not in place, will not be able to support Sentinel data ingest and delivery.
Sentinel-2A Software Requirements definition	In Process	Jan 2015	Apr 2015	Inventory, EE change requests
Sentinel-2A SW Dev initiated	In Process	Feb 2015	Sep 2015	Ingest, Inventory, EE, GloVis, TRAM
Sentinel-2A Launch	Done	Jun 2015	Jun 2015	Launch of first Sentinel-2 satellite
Document Sentinel-2 data characterization	Future	Apr 2015	Oct 2015	Analysis and recommendation for 30m Landsat like product
FY15a Hardware Integration	In Process	May 2015	Aug 2015	Integrate hardware into existing architecture – Network switch, SAN switch, tape drives, ingest server, 1st and 2nd tier disk.
Sentinel-2A System testing	Future	Aug 2015	Dec 2015	System Testing Ingest, Inventory, EE, GloVis, TRAM
Receive L1C 'ramp up' data from ESA	Future	Jul 2015	Dec 2015	Validate process flow and data
Sentinel-2 ORR	Future	Sep 2015	Sep 2015	Operation Readiness Review for production release to support Sentinel-2 archive and distribution.
Sentinel-2 L1C test data availability to a limited audience	Future	Oct 2015	Oct 2015	Test data made available for limited access
FY16 Hardware Procurement initiation	Future	Oct 2015		Hardware procurement outline in FY16 budget
Sentinel-2A L1C data available for download	Future	Jan 2016		Sentinel-2 data release

USGS Sentinel-2 Procurement Status

QTY	HW Description	Status	Comment
1	Sentinel Ingest server	Installed	Waiting on Power and Network
2	T10K-d tape drives	Installed	Waiting on fiber
1	LTO-6 tape drive	Installed	Waiting on fiber
1	SAN 96 port fibre switch	Awarded	
1	1.2TB Solid State Disk to augment Inventory Database	Installed	Waiting on Power and Network
2	V3700 dual ctrl with SSD/SAS -- CR1MSS 1st tier disk (L1C/FRB/WMS) ~35TB	Installed	Waiting on Power and Network
2	V3700 exp tray with SAS disk -- CR1MSS 1st tier disk (L1C/FRB/WMS)	Installed	Waiting on Power and Network
2	V3700 dual ctrl with 12x4TB disk -- CR1MSS 2nd tier disk -- ~2x288TB	Installed	Waiting on Power and Network
12	V3700 additional disk tray with 12x4TB disk -- CR1MSS 2nd tier disk	Installed	Waiting on Power and Network
1	Network infrastructure -- Extreme Black Diamond 8810 core switch	Awarded	
1	Juniper firewall (upgrade to existing asset)	Awarded	
2	Rack for additional hardware	Installed	

USGS

NASA

Tier 1 Timeline

6/22/2015
Sentinel 2a Launch

6/22/2015 - 1/1/2016
Sentinel 2a Data CheckOut

10/1/2014

1/1/2015

4/1/2015

7/1/2015

10/1/2015

1/1/2016
1/15/2016

10/29/2014
EROS S2 Briefing
to LRS Mgmt

12/22/2014
Procurement submitted
by Govt

1/23/2015
TSSC received
procurement task order

3/14/2015
FY15a Hardware
Integration

8/1/ 2015
Preliminary
collection data
Ingest

9/23/2015
Sentinel 2 ORR

10/1/2015
Limited
Data Access
for Cal/Val sites

10/1/2015
FY16 Hardware
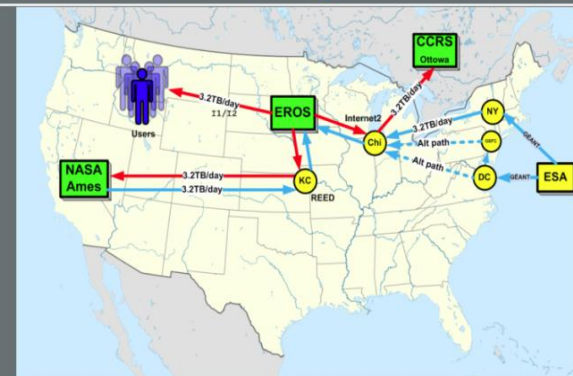Procurement

1/1/2016
Sentinel 2a Data
Download Begins

What's Needed to Make Full Use of S2 for US Investigators?

(1) User access to S2 L1C Data (USGS & ESA)
- Open access through ESA Processing Centers
- USGS S2 archive copy at EROS

(2) MSI characterization & cross-calibration with Landsat-8 OLI (Landsat calibration team & ESA)

(3) Higher-level Products & Science (NASA LCLUC/LcPSO)
  - Prototype merged Landsat + S2 reflectance product (Vermote/LcPSO)
  - Recent NASA LCLUC solicitation for multisource land imaging science
    - Coordinated with ESA SEOM (Scientific Exploitation of Operational Mission) program
    - Multi-year investment in new products from fusion of international systems, including Sentinel-1,2
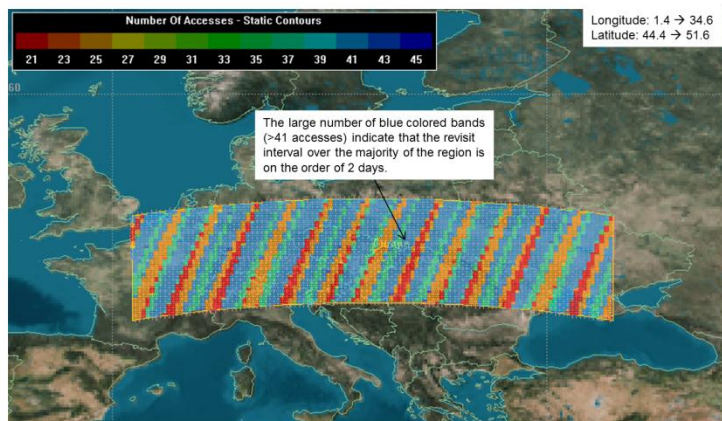
NASA Landsat – Sentinel-2 fusion

- **Merging Sentinel-2 and Landsat data streams will provide <5-day coverage, crucial for agriculture, ecosystem, and land management studies**
- **Goal: "seamless" near daily, 30m surface reflectance record**
- **Cross-calibration, atmospheric corrections, spectral and BRDF adjustments, regridding**
- **Prototype implementation NASA Earth Exchange (NEX)**
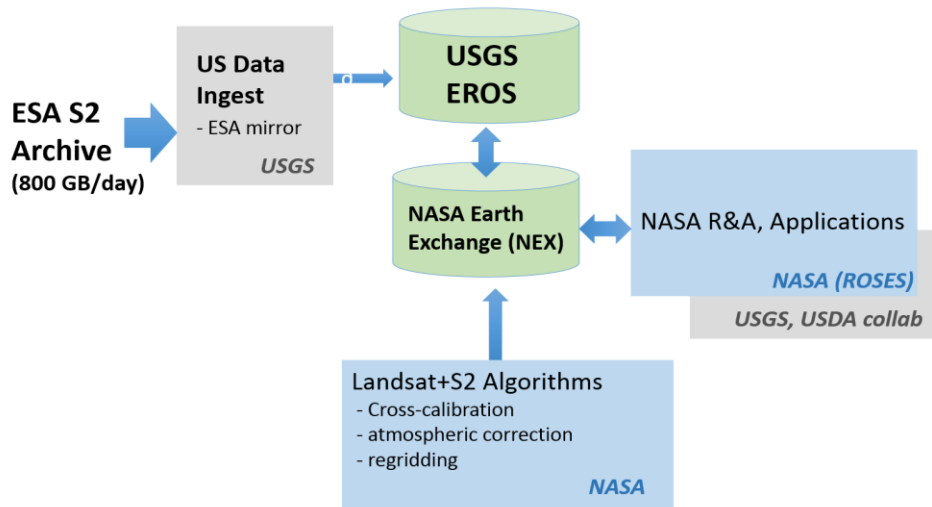

Network Connectivity

Sentinel 2A and B - LDCM Europe

Number Of Accesses - Static Contours

Longitude: 1.4 → 34.6
Latitude: 44.4 → 51.6

The large number of blue colored bands (>41 accesses) indicate that the revisit interval over the majority of the region is on the order of 2 days.

- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

Courtesy Brian Killough, NASA LARC

Proposed Architecture

ESA S2 Archive (800 GB/day)

US Data Ingest
- ESA mirror
USGS

USGS EROS

NASA Earth Exchange (NEX)

NASA R&A, Applications

NASA (ROSES)

USGS, USDA collab

Landsat+S2 Algorithms
- Cross-calibration
- atmospheric correction
- regridding

NASA

MSLI Science Team: 40+ members

PI and CO-Is

Salas, Applied Geosolutions
Torbick, AG

Lang, U Maryland
Jones, USGS
Huang, UMD

Small, Columbia U.
Nghiem, JPL
Greg Yetman, Columbia U.

Friedl, Boston U.
Gray, BU
Melaas, BU

Roy, South Dakota State U.
Kovalskyy, SDSU
Boschetti, U. Idaho

Hansen, U. Maryland
Potapov, UMD

Townshend, U. Maryland
Sexton, UMD
Feng, UMD
Channan, UMD

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Esch, DLR

Eklundh, Sweden

Chuvieco, Spain
Tansey, UK

Defourny, Belgium

Schmullius, Germany

Koetz, ESA,
Sentinel-2 Projects
Coordinator

Dedieu & Hagolle,
CESBIO

Landcover Project Science Office

Masek, NASA, MSLI Project
Scientist

Markham, NASA, calibration team
Helder, SDSU
Czapla-Myers (U. Az)

Schott, RIT
 DIRSIG model, LST

Vermote, NASA GSFC
 Atm. Corr. Team Claverie, U. MD

Woodcock, Boston U.,
 clouds (USPI +1)

Dungan, NASA Ames, NEX
Ganguly, NASA Ames, NEX

NASA Multi-Source Land Imaging PI's

Multisource Imaging of Seasonal Dynamics in Land Surface Phenology	Friedl/BU
Integrating Landsat 7, 8 and Sentinel 2 Data in Improving Crop Type Identification and Area Estimation	Hansen/UMD
Towards Near Daily Monitoring of Inundated Areas Over North America Through Multi-Source Fusion of Optical and Radar Data	Lang / UMD
Prototyping a Landsat-8/Sentinel-2 Global Burned Area Product	Roy / SDSU
Operational Algorithms and Products for Near Real Time Maps of Rice Extent and Rice Crop Growth Stage Using Multi-Source Remote Sensing	Salas / Applied Geosystems
Multi-Source Imaging of Infrastructure and Urban Growth Using Landsat, Sentinel and SRTM	Small / Columbia U
Multi-Source Imaging of Time-Serial Tree and Water Cover at Continental to Global Scales	Townshend / UMD

USGS

NASA
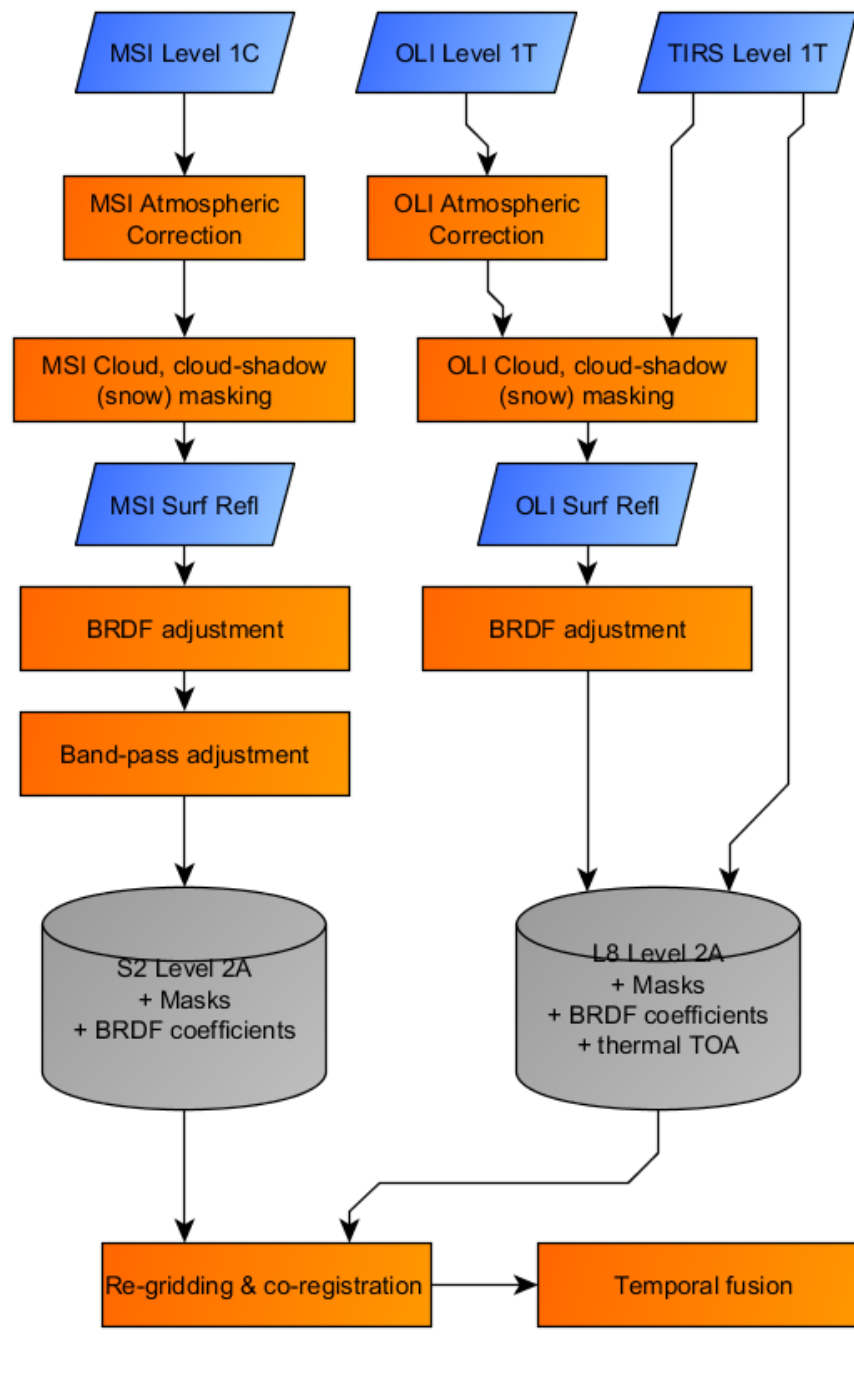
Processing for Landsat/ S2 Harmonization

- Algorithms
    - Atmospheric correction
    - Cloud/shadow masking
    - BRDF adjustment to nadir view
    - Band-pass adjustment to OLI
    - Regridding / Temporal Compositing
        - 30m WELD sinusoidal gridding
        - 6-day, min-AOT composites
            - TIR from best Landsat-8
            - Red-edge from best S2a
            - VSWIR from either
- Processing for test/regional sites on NASA ARC NEX system

Algorithm Approaches

- **Atmospheric Correction**
    - Identical to Landsat-8 OLI algorithm for both L8 & S2
    - AOT retrieved from Coastal/Aerosol and Blue vs Red bands ratios derived from MISR and MODIS
- **Cloud mask**
    - L8: use of thermal, cirrus band and AOT retrieval
        - Updated later to use F-mask
    - S2: use of cirrus band and AOT retrieval
- **BRDF-Adjustment**
    - Adjust all view angles to nadir
    - disagreggation (or downscaling) of VJB BRDF coefficient (Vermote et al. VJB approach);
    - may be updated later to use downscaled MOD43B BRDF (eg Roy et all, 2008)
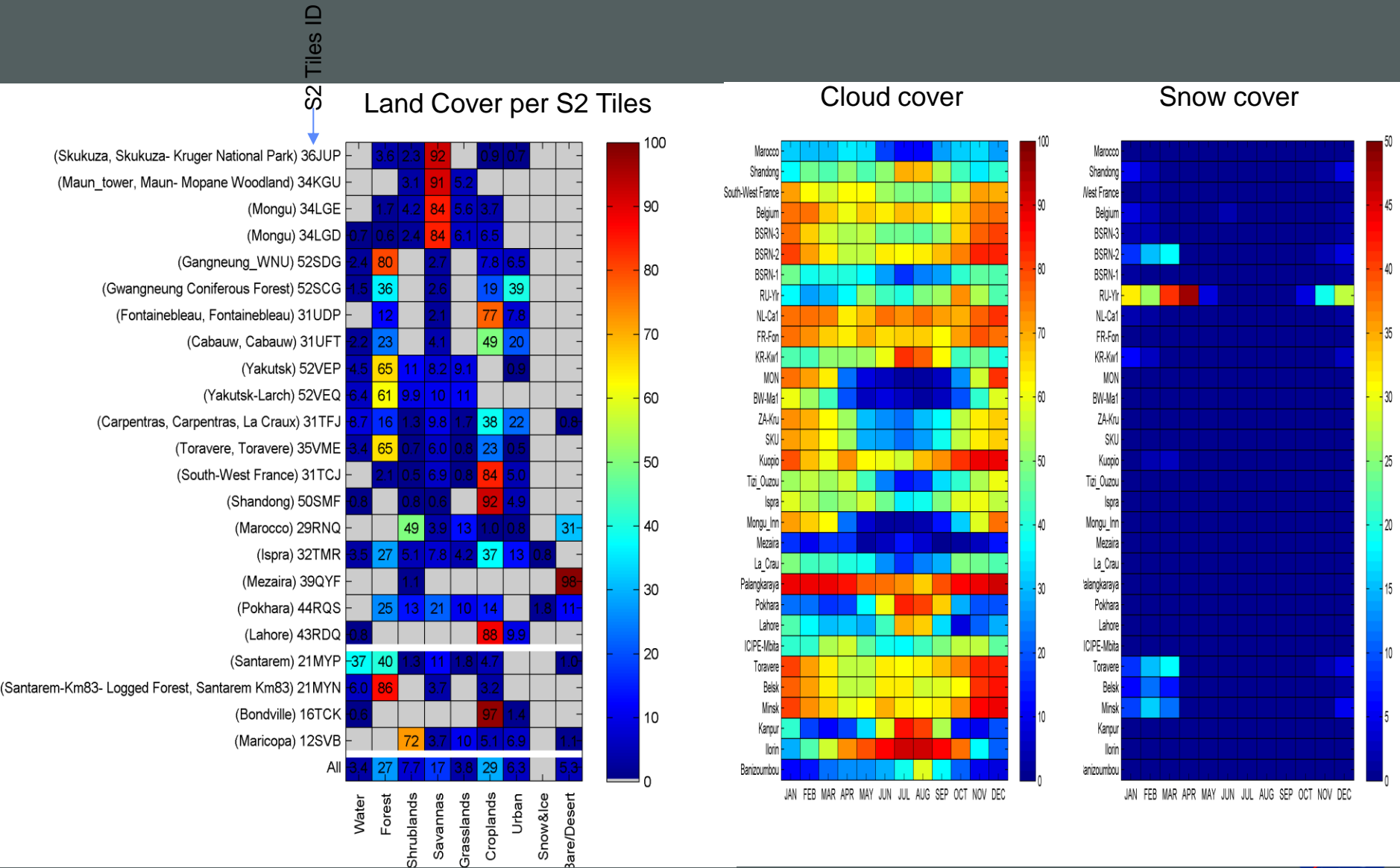- **Spectral adjustment**
    - polynomial regression to modify MSI spectral reflectance to match OLI spectral reflectance
    - based on a global dataset of Hyperion TOC data

USGS

NASA

20 Test Sites pre-selection

- **Sites selected by UM-Boston group:**
    - <u>SAFARI</u>, <u>FLUXNET</u>, <u>BSRN</u>
    - 11 sites
    - Some are combined with Aeronet
- **JECAM**
    - 4 Ag sites proposed with a good potential of in situ data
- **Aeronet**
    - 16 sites proposed based on good recent data record

Sites statistics

Land Cover per S2 Tiles — per S2 tiles 100*100km - Based on IGPB MODIS classification

Cloud cover

Snow cover — (based on MODIS terra CMG products)

Upcoming Milestones

2014 — OLI At-Cor Algorithm (Vermote)

2015

April — OLI At-Cor Algorithm Validated (Vermote)

May — BRDF-adjustment Algorithm (Claverie)

June — MSI At-Cor Algorithm (synthetic data, Vermote)

July — Spectral-adjustment Algorithm (Claverie)

MSI At-Cor Algorithm working with S2 data (Vermote)

Aug — Algorithm integration & NEX deployment (Ju, Ganguly, Dungan)

Sept — Mirroring of S2 data of the 20-30 selected sites (Ganguly, Dungan)

Oct — Start data processing

June 16

S2 Launch

S2 data
(Eurasia + Africa)

S2 Global data

Algorithm development

NEX transitioning

Processing

Thank You